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# Food Supply Chain Traceability: A Multiple Case Study from Alto Tietê Region, Brazil †

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**Abstract:** The traceability is one way to food supply chain transparency. However, when the food is produced by family farmers, considering in communities with low levels of education and lack of TI infrastructure, traceability becomes a major challenge. This article verified the adequacy of the family farmer to the traceability of the food production chain, through the application of a multiple case study in Alto Tietê region, Brazil. The results showed that most farmers have incomplete elementary education (55%), work practically alone in production and they are unable to carry out traceability due to the lack of pesticide registration, which makes implementation unfeasible even if the community has IT infrastructure.

**Keywords:** food safety; production control; process quality; supply chain transparency

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## 1. Introduction

In the past, the pesticide system it was a great innovation for agricultural production. Nowadays, it is a health and environmental problem to food supply chain transparency, mainly to countries that do not have the food supply chain traceability structured. Traceability is priority to increase awareness and prevent food contamination [1]. In Brazil, the vegetables production is characterized by intensive pesticide applied, in many cases analyzed are detected higher limits than allowed by law [2]. In 2018, the Brazilian government agents required the restructuring of the food supply chain to apply traceability into production process [3,4]. However, the Alto Tietê family farmers were not prepared to meet the government requirements.

The main Brazilian food production is from family farms to supply food market. They represent 77% of all agriculture companies and almost 67% of the people employed in agriculture is from family farms [5]. Family farms is defined as the rural activity managed by relatives and the production is carried out by owners with the capital belong to the family that reside on the rural properties [6].

Related the Alto Tietê Region, among 12 cities, Mogi das Cruzes is highlighted due to major number of the rural properties (1,379), and about the schooling of farmers, it is evidenced that almost 3% never attended school, 52% studied up to elementary school, 28% studied up to high school, and 17% studied up to college [7].

The Brazilian vegetable production facing many challenges when the subject is pesticide control and family farmers handling, such as: social condition of the rural people, low level of education, lack of awareness about safety of work in the field, lack of rural infrastructure and digital inclusion, people do not follow good practices of production

and pesticide applied, associated with lack of inspection and a lot of bureaucracy in government processes. Thus, to guarantee the quality of food, a control of pesticide system it is necessary to meets the requirements from market and law ensuring the consumption of fresh products free of chemical residues. Astill et al., warned the number of hospitalizations in USA due to foodborne illness [8].

Aung and Chang, elucidated that traceability is one way to meet the law requirements, and is an effective system to monitoring the food supply chain [9]. Thus, the traceability system offers several advantages and providing information that contribute to food supply chain visibility [1]. Therefore, in this context, the traceability aggregate value to supply chain, due to increase the credibility, improve consumers perception of quality and guarantee the food safety.

In this restlessness we highlighted the research question: RQ—what is the impact of socioeconomic conditions on the adaptation of family farmers to the food chain traceability system? In context of real Brazilian family farm condition, this paper aims to investigate the adequacy of the family farmer to the traceability process to guarantee the food supply chain transparency from farm to fork.

## 2. Materials and Methods

To do this, we conducted a multiple case study with family farmers using the questionnaire that was approved by Ethics Committee (nº 4.570.174/2021). The questionnaire was structured in three parts: first related to social economics aspect [SEA] with 08 closed questions, second related the productions process aspect [PPA] with 09 closed questions, and the last part related to food supply chain traceability and the governments requirements [FSCT] composed by 18 open-closed questions, and this total 08 questions focus on property with traceability system.

The data was collected in March 2021 following the design of interview, Figure 1.

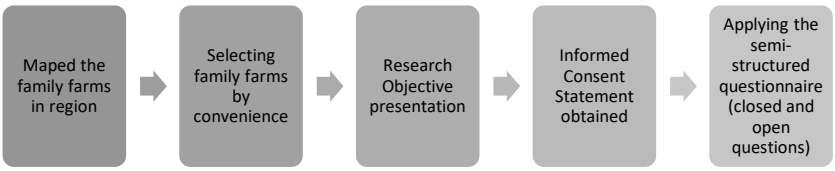



**Figure 1.** Steps of data collection procedure.

Considering the interview design all family farmers should answered about SEA and PPA, and full part of FSCT if the property used the traceability system. The farmers that agreed to participate as a volunteer in research were clarified about research objective, risks and benefits.

*Data Analysis*

We carried out the description statistics to explore the table and graphic results, using a frequency distribution tables and proportionality study. To answer the RQ, we investigated the association among socioeconomic variables and traceability system adequation in family farmers property, using the Chi-squared ($\chi^2$), Equation (1) [10].

$$\chi^2 = \sum_{i=1}^{I} \sum_{j=1}^{J} \frac{(Oij - Eij)2}{Eij}, \quad (1)$$

Where, $I$ = number of variable categories of $X$; $J$ = number of variable categories of $Y$; $Oij$ = number of observations ($i$ = categories of variable $X$; $j$ = categories of variable $Y$); $Eij$ = expected frequency of observations ($i$ = categories of variable $X$; $j$ = categories of variable $Y$). In this analysis, we applied the 95% confidence interval and $p$-value = 0.05.

## 3. Results

Nine family farmers participated the research, and the mainly results showed that the most farmers did not finish the elementary school (55%), which this could affect the process to apply traceability, Table 1. Our results are similar with the previously literature review [7]. We did not find association among level of education and family income ($\chi^2$ = 6.3; $p$ = 0.09789), but we noted that farmers with incomplete elementary school have a family income round from 4 to 5 basic salary and farmers with high school or above from 7 to 8 basic salary.

**Table 1.** Highlighted results on socioeconomic variables, values in %.

| Socioeconomics Variables | Highlighted Results | Values in % |
|---|---|---|
| Gender | Male | 80 |
| Age | Above 46 years old | 55 |
| School | Elementary school | 55 |
| Family income | From 3 to 7 basic salary | 67 |
| Family size | From 3 to 4 people | 55 |
| Legal condition of farmer | Independent farmer | 67 |
| Work experience, in years | Above 31 | 55 |
| Production system | Conventional production | 89 |
| People out of family working in farm | No, just family members | 67 |

We found association among farmer work experience and family income ($\chi^2$ = 13.5; $p$ < 0.05), and we observed that the majority showed the income above 3 basic salary and have above 21 years of agriculture work experience. Considering production process, 89% of farmers applying the conventional techniques and they did not receive any technical assistance from government. Analyzing the agriculture pesticide applied by farmers, such as fungicide, insecticide and/or herbicide, we did not find association among farmer work experience in agriculture and type of pesticide applied, Table 2.

**Table 2.** Distribution of farmer work experience in agriculture and type of pesticide applied (values in %).

| Farmer Work Experience, in Years | Biological | Organic | Chemical |
|---|---|---|---|
| From 11 to 20 | 7.14 | | 14.28 |
| From 21 to 30 | | 7.14 | 7.14 |
| From 31 to 40 | | 7.14 | 14.28 |
| Above 41 | | 21.42 | 21.42 |

($\chi^2$ = 6.73; $p$ = 0.3467).

From nine farmers, there is one farm that showed more technological and capacity to agricultural produce and have people out of family working in a farm together family members, with the use of tractors, seeders and fertilizers, unlike the others that use only tractors.

*Local Farmers and Traceability System Implementation*

Local farmers produce many kinds of fresh food such as onion, parsley, cabbage, potato, carrot, lettuce, radish, chard, kale, endive, mustard, coriander, and so on. Majority farmers work alone in agricultural production and sometimes family members helped them with some production procedure. Thus, the farmers do not have free time to dedicate another activity, such as: education, training and practice some hobby.

Farmers informed that they are interested in learning new things in computer and other tools that helped them to control and management the agricultural production. Some farmers participating of the Rural Association of the Jundiapeba Farmers, and Re-

gion [APROJUR], where one time by week farmers has a meeting to discuss agricultural subjects, like traceability system, digital inclusion, new tools of production control etc. Our results evidenced that all farms have internet access, however 88% of farmers do not have basic computer knowledge.

To perspective the traceability system implementation, the technological tools is essential for a successful information control and production process. Despite all famers have knowledge about law of traceability obligation [3][4], just one farmer applied the traceability, but in 1% of all production area, in another words, 99% of production is not traced.

Considering the question about the criteria to comply the law and the difficult level, Figure 2, we noted that the majority have condition to provide the information technological infrastructure [TI], pesticide control and documentation and supply registration and information, but farmers highlighted the high difficult to train people involved in agricultural production, provide food identification and data capture and exchange along of supply chain. We also observed that 50% is worried with return of capital investment to traceability system implementation.

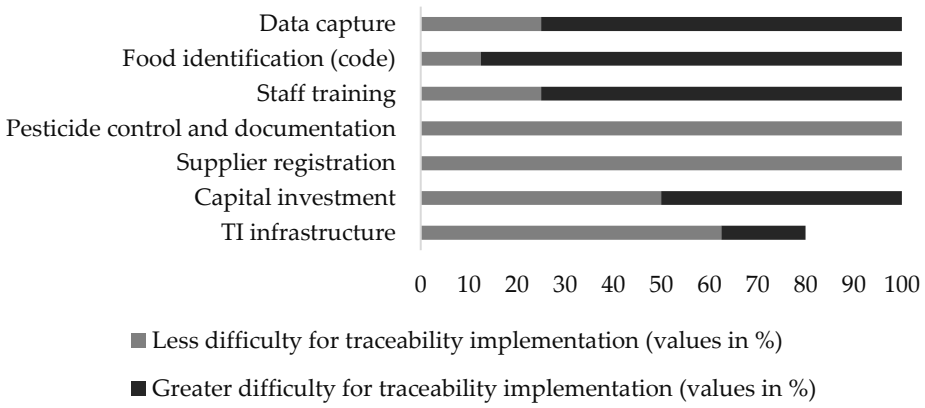
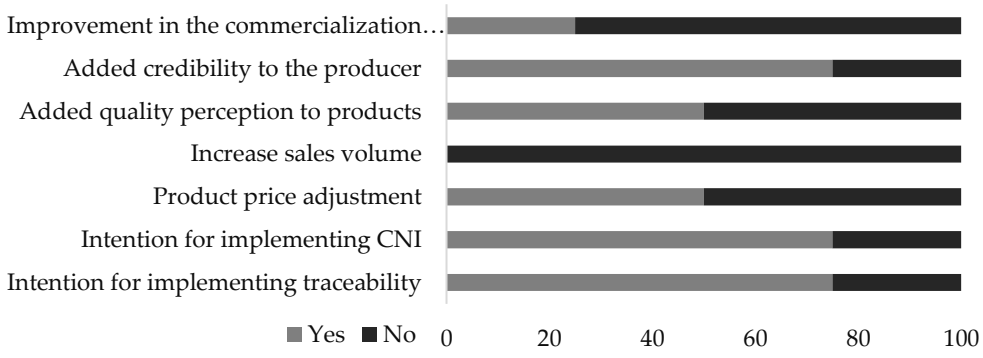



**Figure 2.** Degree of difficulty to traceability system implementation.

According to the farmer that applied traceability in 1% of this production, the most difficult to traceability system implementation is related to "our legislation, because there is no registration of all the pesticide used in agricultural production, such as for the cultivation of onion, parsley, coriander, basil and mint". On the other hands, there are pesticide that could be applied by group of vegetable from same family, such as: cabbage, can be used for cauliflower, but it does not have the same effect due to not proper for product.

We also did not find association among education level and traceability criteria implementation, but we noted association among traceability criteria implementation and farmers perception ($p < 0.05$), Figure 3.



$\chi^2 = 16.0$; $p = 0.0137$; CNI = Brazilian traceability law

**Figure 3.** Traceability criteria implementation and farmers perception.

The majority of farmers agreed with the traceability is important to vegetable supply chain, however they do not have "faith" in procedure, and they did not see the benefits related adjusted sale price, increase sales volume or process improvement, due to the actual Brazilian sales design of fresh food, that included intermediaries in the supply chain.

Local farmers were emphatic in answering that it is the responsibility of the state, since the laws are in their hands, and they must provide support, whether social, technical legal or financial. One of the participating farmers replied: "Yes, public management should be the first to provide inputs and infrastructure for adaptation", another reported: "There are difficulties in relation to the high amounts paid in inputs for production, and with traceability it would be more an addition that would not be transferred".

## 4. Discussion

The Brazilian agriculture has been facing a depopulation process over the years due to hard rural work and low pay (dissatisfaction), as well as the young's move to urban city in search of better living conditions, however this puts at risk the succession of the family farmer business [11]. Fonseca et al. and Kageyama, contributed to discussion elucidating that this dissatisfaction is related the rural socioeconomic factors, like education and family income, both could be help farmer to invest in production system and use the management strategic to comply government and market requirement [12,13].

In addition, Brazilian production in rural areas is facing many challenges to conduct the agricultural activities, such as hard work every day in production with few people, technology access, costs of raw-material and in commercialization due to low price of the commodities that impact on family income [11]. These are a critical social problem that could affect the family farmer condition to adopt traceability. According to Astill *et al.,* to complete traceability system sixteen drivers should be considered by food supply chain, such as food safety and quality, as well as food waste or loss, information quality, health and wellbeing standards, regulation/certification, and among all of consumer awareness, market protection and competitive advantage [8]. So, it is not a simple task to require from family farms without give the structural and support to.

Patidar et al. highlighted that traceability provides information about food across each process of supply chain, included the procurement, production and distribution [1]. Authors explained that a basic traceability system should consider three components as data identification, database management system, and a data exchange among actors of supply chain [1], and Astill et al. complemented that information must be available from origin to consumers and beyond of supply chain included many aspects of agricultural procedures, transport, packaging and storage conditions [8].

There are few practices of work involving family farmers and technology application using control and monitoring technical, which cause a series of obstacles in the implementation of traceability systems [14]. Thus, knowing the real condition of Brazilian family farmers, the traceability could become a barrier to entry for producers in the market, if they are unable to adapt, due to the cost of the infrastructure needed to carry out the monitoring and training of the personnel involved in the activity [14]. A dangerous way is contribute to the formation of a parallel market for non-traceable and uncontrolled food.

In addition, the difficulty to traceability system implementation will cause a family farmers resistance to new technology and good production practices [15]. Results from Carvalho research revealed that 24% of farmers have accessed to internet at houses or at Rural Association [16]. Differently from our results, all farmers that contributed with this paper have internet access at home, but do not have knowledge to use.

In generally, the family farmers agreed that traceability system is important to food control and monitoring process, but in current conditions does not function as well as

projected, due to: (1) lack of pesticide registration to use in agricultural production; (2) current commercialization design that allow lots product merge and this is inconsistent with traceability premise; (3) lack of government support and training people; and (4) high investment by family farmer and no payback expectative, in other words, the costs is not transfer to the market.

In conclusion, the traceability in Alto Tietê food supply chain going to be possible when the government creates a structure to adequate the pesticides system, the traceability law and provide the training and support to rural families involved in food supply chain. Despite to did not find association with education level and criteria to traceability system implementation, 55% of the family farmers studied up to elementary school and the major do not have skills to work with computers to register the production information.

**Institutional Review Board Statement:**

**Informed Consent Statement:**

**Data Availability Statement:**

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